

CLAIMS

What is claimed is:

1. An electrolytic cell comprising:
a first container containing an acidic catholyte, wherein the catholyte comprises a metal in complex with a complexing agent, and wherein a cathode is at least partially disposed within the catholyte;
a pump fluidly coupled to the first container and moving the catholyte across the cathode at a predetermined flow velocity;
a second container containing an anolyte, wherein the second container is at least partially disposed in the catholyte, wherein the second container comprises a separator that separates the catholyte from the anolyte, and wherein the second container further comprises an anode; and
wherein the cathode and the second container are positioned relative to each other such that a flow path between the second container and cathode is formed from which the metal is deposited onto the cathode at non-current limiting conditions at the flow velocity.
2. The electrolytic cell of claim 1 wherein the first container has a first opening that receives the catholyte and a second opening that discharges the catholyte after the catholyte has contacted the second container.
3. The electrolytic cell of claim 2 wherein the first container is at least partially disposed in a tank that receives the catholyte from the second opening and that provides the catholyte to the first opening.
4. The electrolytic cell of claim 1 wherein the acidic catholyte comprises sulfuric acid, and wherein the complexing agent is ethylenediamine tetraacetic acid.
5. The electrolytic cell of claim 1 wherein the cathode comprises titanium, and wherein the anode comprises lead or iridium oxide coated titanium.

6. The electrolytic cell of claim 1 wherein the anolyte is provided to the second container from an anolyte circulation tank, and wherein the anolyte comprises sulfuric acid.
7. The electrolytic cell of claim 1 wherein the separator comprises a diaphragm or an ion exchange polymer.
8. The electrolytic cell of claim 1 wherein the metal has a concentration of less than 5000 ppm.
9. The electrolytic cell of claim 1 wherein the metal has a concentration of less than 500 ppm.
10. The electrolytic cell of claim 1 wherein the predetermined flow velocity of the catholyte across the cathode is at least 0.08 m/sec.
11. The electrolytic cell of claim 1 wherein the metal is deposited as a smooth film.
12. An electrolytic cell comprising:
an anode, a cathode, and an electrolyte comprising a metal in complex with a complexing agent;
a pump fluidly coupled to the electrolytic cell and moving the electrolyte between the anode and cathode at a predetermined flow velocity; and
wherein the anode and the cathode are positioned relative to each other such that a flow path is formed between the anode and cathode from which the metal is deposited onto the cathode at non-current limiting conditions at the flow velocity.
13. The electrolytic cell of claim 12, wherein the cathode is disposed in a cathode container that contains the electrolyte.
14. The electrolytic cell of claim 13, wherein the anode is disposed in an anode container that includes an anolyte that is circulated between the anode container and an anolyte circulation tank, and wherein the anode container is at least partially disposed in the cathode container.

15. The electrolytic cell of claim 13 wherein the anode container includes a separator that comprises a diaphragm or an ion exchange polymer.
16. The electrolytic cell of claim 12 wherein the cathode container is in fluid communication with a tank that contains the electrolyte.
17. An electrolytic cell comprising:
 - an electrolyte reservoir that contains an electrolyte in which lead is complexed with a complexing agent;
 - a first container at least partially disposed within the electrolyte reservoir, wherein the first container further includes a cathode, a first opening that receives the electrolyte from the electrolyte reservoir, and a second opening that provides the electrolyte back to the electrolyte reservoir;
 - a second container at least partially disposed within the first container, wherein the second container further includes an anolyte and an anode, wherein the anolyte in the second container is separated from the electrolyte in the first container by a separator; and
 - a pump fluidly coupled to the electrolyte reservoir and moving the electrolyte from the electrolyte reservoir to the first container via the first opening at a rate effective to prevent formation of a diffusion layer in a flow path that is formed between the second container and the cathode.
18. The electrolytic cell of claim 17 wherein the complexing agent is ethylenediamine tetraacetic acid and wherein the electrolyte further comprises an acid.
19. The electrolytic cell of claim 17 wherein the separator is a diaphragm or an ion exchange polymer.
20. The electrolytic cell of claim 17 further comprising an anolyte circulation tank that is fluidly coupled to the second container.

21. An electrolytic cell comprising:
an anode and a cathode, both at least partially in electrical contact with an electrolyte that includes a metal in complex with a complexing agent, wherein the metal is present in the electrolyte at a concentration of less than 5000 ppm; and
a pump that moves the electrolyte in a flow path between the anode and the cathode at a flow velocity at which the metal is plated onto the cathode in form of a smooth film under non-current limiting conditions.
22. The electrolytic cell of claim 21 wherein the pump optionally provides a second flow velocity that is greater than flow velocity, and wherein the metal is plated onto the cathode at the second flow velocity in form other than the smooth film.
23. The electrolytic cell of claim 21 wherein the metal is present in the electrolyte at a concentration of less than 500 ppm.
24. The electrolytic cell of claim 21 wherein the metal is present in the electrolyte at a concentration of less than 100 ppm.
25. The electrolytic cell of claim 21 wherein the form other than the smooth film is a powdery deposit or a dendritic form.
26. A method of immobilizing lead ions in soil previously treated with a complexing agent, comprising admixing a ferric chloride containing solution to the soil.